Zebra Mussels, Blue-Green Algal Blooms, and Other Water Quality Problems in The Great Lakes

Microcystis Blooms Return

Nuisance blooms of the potentially toxic blue-green alga *Microcystis* have returned to Lake Huron's Saginaw Bay and Lake Erie. Saginaw Bay has experienced blooms every summer since 1994, and Lake Erie experienced a bloom resembling a thick slick of grass-green paint that extended over the entire surface of the western basin during September 1995 (Figure 1). Blooms of *Microcystis* and other blue-greens have not occurred since the 1970's and early 1980's when phosphorus controls reduced phosphorus inputs to the Great Lakes. Excessive phosphorus is the usual culprit for nuisance blooms, but now other causes must be considered.

These recent blooms have occurred a few years after the invasion of zebra mussels in the Great Lakes. The zebra mussel's prodigious filtering makes the water clear by removing particles. Even in years when blooms have occurred, zebra mussel filtering caused the water to be very clear during spring and early summer before the blooms took off. A similar pattern of *Microcystis* or other blue-green blooms is now being seen in some small lakes that have been invaded by mussels.

Blooms of *Microcystis* are of concern because *Microcystis* is poor food for the aquatic food chain and because it contains a potent toxin called microcystin that is harmful to the aquatic food chain, including fishes, and to waterfowl or other animals that might drink the untreated water. The Lake Erie and Saginaw Bay strains of *Microcystis* are toxic; however, there has to be a high concentration of *Microcystis*, such as that found in a thick surface scum, to be dangerous to wildlife or pets drinking the water. Such conditions can occur when *Microcystis*, which has gas vacuoles, floats up to the surface under calm conditions and is concentrated by winds or currents in shallow areas near shore.

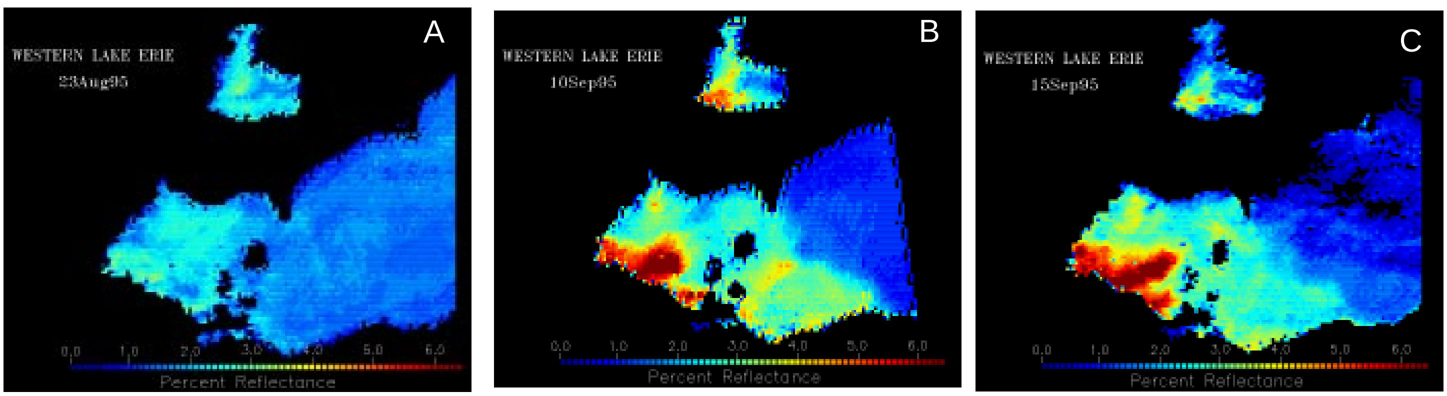


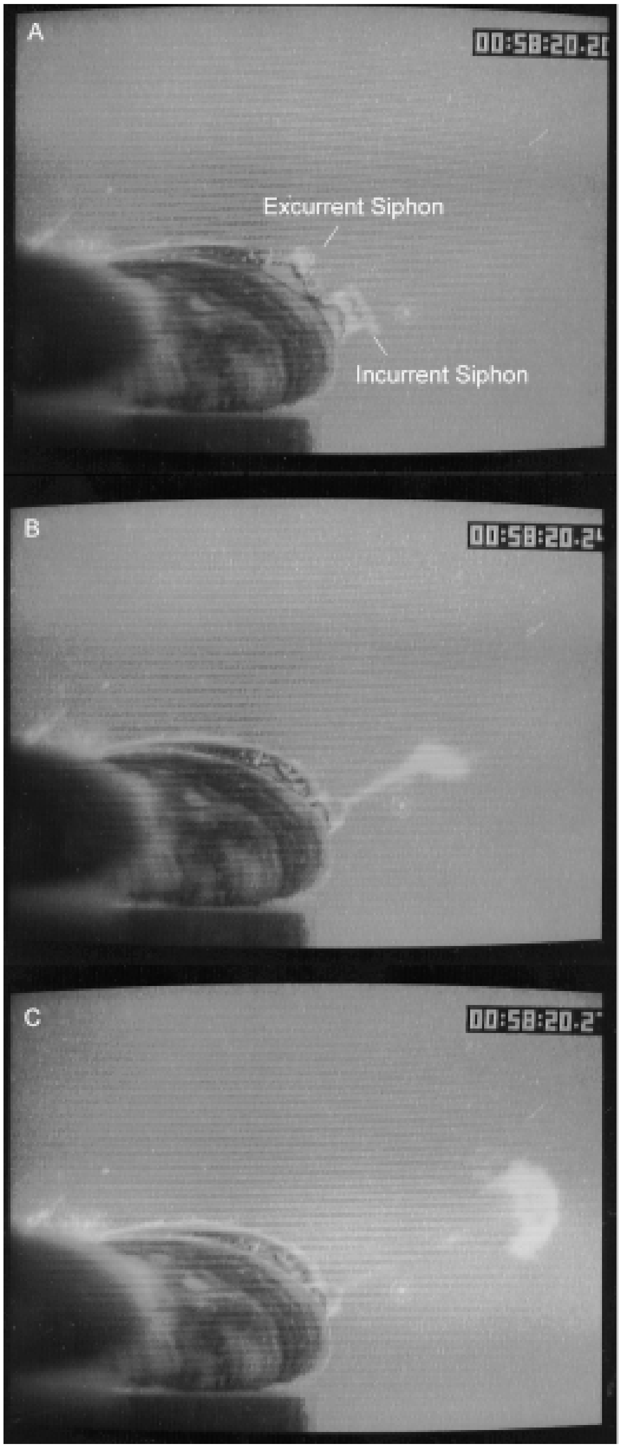
Figure 1. NOAA CoastWatch satellite images of western Lake Erie showing development of the Microcystis *bloom as measured by percent reflectance, which is a measure of concentration of particles —in this case Microcystis —in the water. Little reflectance was seen on (A) 23 Aug 95, before the bloom got underway. Concentration of* Microcystis *started to increase in the southwestern part of the western basin (B) (10 Sep 95) and continued until much of the whole basin was covered (C) (15 Sep 95). The water body near the figure captions is Lake St. Clair.*

The Zebra Mussel Connection

The extensive monitoring and experimental program of NOAA's Great Lakes Environmental Research Laboratory (GLERL) on Saginaw Bay as well as a newly initiated program supported by the Lake Erie Protection Fund (LEPF) are providing hypotheses and some answers to explain the zebra mussel-*Microcystis* connection. GLERL is one of many agency and academic participants in the LEPF program.

Experiments at GLERL with water from Saginaw Bay and Lake Erie have shown that zebra mussels selectively filter and reject phytoplankton so as to promote and maintain *Microcystis* blooms. Using special video equipment, GLERL showed that mussels filter the water whether or not *Microcystis* is present, but they spit *Microcystis* back into the water while at the same time eat other algae (Figure 2). Thus, the competitors of *Microcystis* are removed. This probably explains why *Microcystis* is Saginaw Bay's dominant alga in summer. At the same time this selective feeding process is occurring, the mussels are excreting nutrients (phosphate and ammonia) as part of digestion and metabolic processes. These nutrients, in turn, serve to fertilize further growth of *Microcystis*. A major question is whether nutrients excreted by mussels are a major promoter of *Microcystis* blooms. GLERL's work in Saginaw Bay suggests that phosphate (the limiting

The zebra mussel (Dreissena polymorpha).



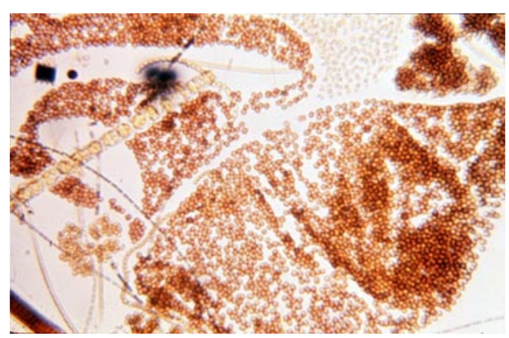
nutrient) excretion by mussels is not high enough to directly promote blooms, therefore, present research focuses on finding the source of the phosphorus that allows the *Microcystis* to reach such high concentrations. In contrast, direct nutrient excretion could be important in Lake Erie where phosphorus concentrations in both water and algae (their food) are higher than in Saginaw Bay. We are also beginning to examine the possibility that zebra mussels have fundamentally altered ecosystem phosphorus cycling so it becomes available for summer blooms.

Figure 2. Zebra mussel expelling Microcystis *as pseudofeces. (A) Mussel filtering with siphons in normal position. (B) Excurrent siphon retracted and incurrent siphon starting to expel the* Microcystis *as pseudofeces. (C) Pseudofeces ejected.*

Other Water Quality Problems

Microcystis can create taste and odor problems in drinking water supplies. *Microcystis* is not eaten by grazers, and as *Microcystis* uses up all the nutrients it dies and sinks to the bottom where it is decomposed by bacteria, including actinomycetes. Actinomycetes produce the musty taste and odor compounds geosmine and MIB (methyl-isoboreol) that give a foul taste to drinking water. Many municipal water supplies throughout the Great Lakes are now reporting taste and odor problems. Besides *Microcystis*, other algae and aquatic plants, including filamentous algae, can also be linked to taste and odor problems. Because zebra mussels clear the water of particles, more light reaches the bottom allowing these algae to better grow. As these algae decompose, they too can be food for actinomycetes to create geosmine and MIB. In addition, some filamentous blue-green algae are themselves odor producers.

Increased light penetration to the bottom also stimulates the growth of macrophytes (rooted aquatic weeds). These weeds can become a problem in the shallow areas of some lakes or over broad areas of shallow lakes. For example, macrophytes increased dramatically in Lake St. Clair since the zebra mussel became established. Under the right conditions, these weeds have detached, washed up on shore, and fouled beaches.



Microcystis.

What Needs To Be Done?

Our work suggests that zebra mussels are responsible for recent water quality problems in the Great Lakes, and it is important to prevent the mussels from spreading. Impacts of the mussels depend on how much hard substrate is available for the mussels to attach to and grow on, depth of the lake, degree of eutrophy (nutrient enrichment), and other factors. Zebra mussels are not expected to be a problem in the deep, cold, and nutrient-poor waters of Lake Superior. Unfortunately, there are many factors that we just do not understand. Mitigation of impacts may involve, for example, more stringent controls on nutrients so the potential for blooms of *Microcystis* and other nuisance species is diminished. Although water quality may not be greatly impacted in the deeper Great Lakes, there may be undesirable effects to the food web. As zebra mussels, and their close relatives the quagga mussels, colonize deeper waters, they will intercept algae settling out to the bottom that would normally feed other benthic animals such as amphipods, which are important food for fishes. Only further monitoring and experiments on systems like Saginaw Bay will yield insight so that sensible mitigation strategies can be developed.